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# T03 Planning and Uncertainty

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## 目录

# 1 Situation Calculus

(a)$\forall s \forall o\ at(o, l1, s) \rightarrow \neg at(o, l2, s)$

(b)$s_0 : \neg lightOn(s_0) \wedge at(b_1, r_2, s_0) \wedge at(b_2, r_3, s_0) \wedge at(shakey, r_1, s_0) \wedge adj(r_1, r_2) \wedge adj(r_2, r_3)$

$goal : \exists s\ lightOn(s) \wedge at(b_1, r_1, s) \wedge at(b_2, r_2, s)$

(c) $walkTo(loc_1, loc_2) :$

$\forall s\ at(shakey, loc_1, s) \wedge adj(loc_1, loc_2) \rightarrow \neg at(shakey, loc_1, do(walkto(loc_1, loc_2), s)) \wedge$

$at(shakey, loc_2, do(walkto(loc_1, loc_2), s))$

$push(box, loc_1, loc_2) :$

$\forall s\ at(shakey, loc_1, s) \wedge at(box, loc_1, s) \wedge adj(loc_1, loc_2) \rightarrow \neg at(shakey, loc_1, do(push(box, loc_1, loc_2), s)) \wedge$

$\neg at(box, loc_1, do(push(box, loc_1, loc_2), s)) \wedge at(shakey, loc_2, do(push(box, loc_1, loc_2), s))$

$\wedge at(box, loc_2, do(push(box, loc_1, loc_2), s))$

$turnOn :$

$\forall s\ at(shakey, r_1, s) \wedge at(b_1, r_1, s) \wedge at(b_2, r_2, s) \rightarrow lightOn(do(turnOn, s))$

(d) 1.$\neg lightOn(S_0)$

2.$at(b_1, r_2, S_0)$

3.$at(b_2, r_3, S_0)$

4.$at(shakey, r_1, S_0)$

5.$adj(r_1, r_2)$

6.$adj(r_2, r_3)$

7.$(\neg at(shakey, loc_1, S), \neg adj(loc_1, loc_2), \neg at(shakey, loc_1, do(walkingto(loc_1, loc_2), S)))$

8.$(\neg at(shakey, loc_1, S), \neg adj(loc_1, loc_2), \neg at(shakey, loc_2, do(walkingto(loc_1, loc_2), S)))$

9.$(\neg at(shakey, loc_1, S), \neg at(box, loc_1, S), \neg loc_1, loc_2, \neg at(shakey, loc_1, do(pushing(box, loc_1, loc_2), S)))$

10.$(\neg at(shakey, loc_1, S), \neg at(box, loc_1, S), \neg loc_1, loc_2, \neg at(box, loc_1, do(pushing(box, loc_1, loc_2), S)))$

11.$(\neg at(shakey, loc_1, S), \neg at(box, loc_1, S), \neg loc_1, loc_2, at(shakey, loc_2, do(pushing(box, loc_1, loc_2), S)))$

12.$(\neg at(shakey, loc_1, S), \neg at(box, loc_1, S), \neg loc_1, loc_2, at(box, loc_2, do(pushing(box, loc_1, loc_2), S)))$

13.$(\neg at(shakey, r_1, S), \neg at(b_1, r_1, S), \neg at(b_2, r_2, S), lightOn(do(turnOn, S)))$

14.$(\neg lightOn(z), ans(z))$

先后令 $z = do(turnOn, S)$，令 $S = do(push(b_1, r_2, r_1, S)), S = do(push(b_2, r_3, r_2, S)), s = do(walkto(r_2, r_3), S), s = do(walkto(r_1, r_2, S), S = S_0$, 可归结得到:

$ans(do(turnOn, do(push(b_1, r_2, r_1), do(push(b_2, r_3, r_2), do(walkto(r_2, r_3), do(walkto(r_1, r_2, S_0))))))$

## 2 STRIPS and Reachability Analysis

(a) $KB = \{clear(p2), clear(p3), clear(d1), on(d1, d2), on(d2, d3), on(d3, p1)\}$

$move(x, a, b)$

$Pre : \{on(x, a), clear(x), clear(b), smaller(x, b)\}$

$Add : \{on(x, b), clear(a)\}$

$Dels : \{on(x, a), clear(b)\}$

$moveTwo(x, y, a, b)$

$Pre : \{on(x, y), on(y, a), clear(x), clear(b), smaller(y, b)\}$

$Add : \{on(y, b), clear(a)\}$

$Dels : \{on(y, a), clear(b)\}$

$Goal = \{on(d3, p3), clear(p1), clear(p2), on(d1, d2), on(d2, d3), clear(d1)\}$

(b) $S_0 = \{clear(p_2), clear(p_3), clear(d_1), on(d_1, d_2), on(d_2, d_3), on(d_3, p_1)\}$

$A_0 = \{move(d_1, d2, p_2), move(d_1, d2, p_3), moveTwo(d_1, d_2, d_3, p_2), moveTwo(d_1, d_2, d_3, p_3)\}$

$S_1 = \{clear(p_2), clear(p_3), clear(d_1), on(d_1, d_2), on(d_2, d_3), on(d_3, p_1), on(d_1, p_2), clear(d_2), on(d_1, p_3)$
$, on(d_2, p_2), clear(d_3), on(d_2, p_3)\}$

$G = \{on(d3, p3), clear(d3), clear(p2), on(d1, d2), on(d2, d3), clear(d1)\}$

$G_N = \{clear(d3)\}$

$G_P = \{on(d_2, d_3), clear(p_2), on(d_1, d_2), clear(d_1)\}$

$A = \{moveTwo(d_1, d_2, d_3, p_2)\}$

$CountAction(G, S_1) = 1 + CountAction(G, S_0)$

$A_1 = \{move(d_1, d2, p_2), move(d_1, d2, p_3), moveTwo(d_1, d_2, d_3, p_2), moveTwo(d_1, d_2, d_3, p_3), move(d_1, d_2, d_3),$
$move(d_2, d_3, p_2), move(d_2, d_3, p_3), move(d_3, p_1, p_2), move(d_3, p_1, p_3), move(d_1, p_2, d_2), move(d_1, p_2, d_3),$
$move(d_1, p_2, p_3), move(d_1, p_3, p_2), move(d_1, p_3, d_2), move(d_1, p_3, d_3), move(d_2, p_2, d_3), move(d_2, p_2, p_3),$
$move(d_2, p_3, p_2), move(d_1, p_3, d_3), moveTwo(d_2, d_3, p_1, p_2), moveTwo(d_2, d_3, p_1, p_3)\}$

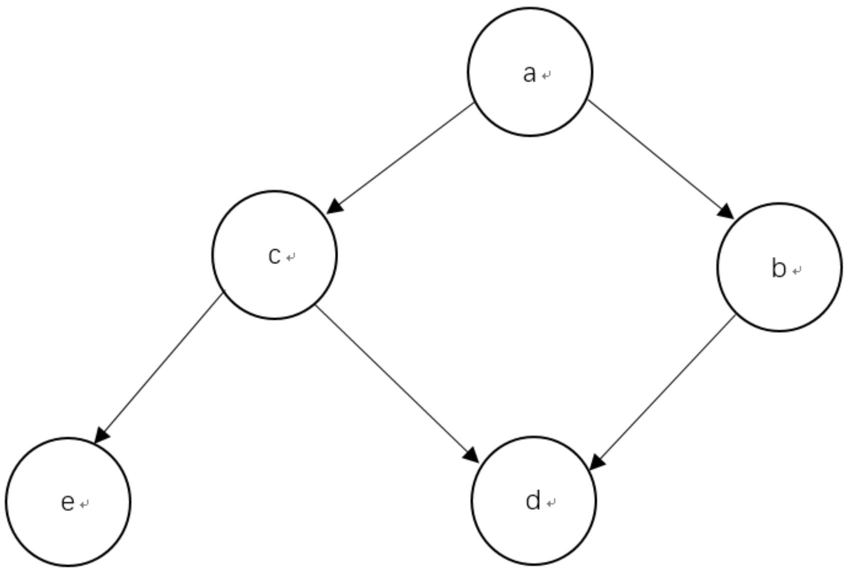
$S_2 = \{clear(p_1), clear(p_2), clear(p_3), clear(d_1), clear(d_2), clear(d_3), on(d_1, d_2), on(d_2, d_3)$
$, on(d_1, p_1), on(d_1, p_2), on(d_1, p_3), on(d_2, p_1), on(d_2, p_2), (d_2, p_3), on(d_3, p_1)$
$, on(d_3, p_2), on(d_3, p_3), \}$

$G = \{on(d3, p3), clear(d3), clear(p2), on(d1, d2), on(d2, p3), clear(d1)\}$
$G_N = \{on(d3, p3)\}$
$G_P = \{clear(d3)\}$
$A = \{move(d_3, p_1, p_3)\}$
$CountAction(G, S_2) = 1 + CountAction(G, S_1) = 2$

# 3 Bayesian Networks

1.

(a)




(b) 通过链式法则，有：

$p(a, c, e) = p(e|a, c)p(c|a)p(a)$

由独立假设，得:

$p(a, c, e) = p(e|c)p(c|a)p(a)$

(c) $P(a, b, c|\neg d, e) = 0.009$

$P(a, b, \neg c|\neg d, e) = 0.006$

$P(a, \neg b, c|\neg d, e) = 0.048$

$P(a, \neg b, \neg c|\neg d, e) = 0.048$

$P(\neg a, b, c|\neg d, e) = 0.003$

$P(\neg a, b, \neg c|\neg d, e) = 0.003$

$P(\neg a, \neg b, c|\neg d, e) = 0.065$

$P(\neg a, \neg b, \neg c|\neg d, e) = 0.819$

(d) 由 (c) 可知，

$P(a|\neg d, e) = P(a, b, c|\neg d, e) + P(a, b, \neg c|\neg d, e) + P(a, \neg b, c|\neg d, e) + P(a, \neg b, \neg c|\neg d, e) = 0.111 < 0.2$

故，当一名学生没有奖学金，但是在同学之中受欢迎时，他沉迷游戏的概率下降。

2.

(a) $relevant\ variables : A, B, C, E$

$elimination\ order : A, B, C, E$

$Step1 : Compute\ \ \&\ \ Add\ f_1(b, c) = \sum_a f(a)f(a, b, c)$

$Remove : f(a), f(a, b, c)$

$Step2 : Compute\ \ \&\ \ Add\ f_2(c) = \sum_b f(b)f_1(b, c)$

$Remove : f(b), f_1(b, c)$

$Step3 : Compute\ \ \&\ \ Add\ f_3(e) = \sum_c f_2(c)f(c, e)$

$Remove : f_2(c), f(c, e)$

$P(e) = 0.5032$

(b) $Restriction : replace\ f(c, f) with f_4(C) = f(c, \neg f)$

Step 1 and Step 2 are the same as part(a)

$Step3 : Compute\ \ \&\ \ Add\ f_3(e) = \sum_c f_2(c)f_4(c)f(c, e)$

$Remove : f_2(c), f_4(c), f(c, e)$

$P(e|\neg(f)) = 0.6912$